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What Causes the Changes in Cathodoluminescence Intensity in Natural Zircons?

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Cathodoluminescence (CL) detectors connected to scanning electron microscopes or electron microprobes are a very useful tool in geosciences. Especially for the geochronological work on zircons CL documentation of the internal structures is rather important. Since several years CL investigations are established in combination with U-Pb dating of zircons. CL offers a lot of information about the growing history of the investigated crystals. Beside homogeneous zoning structures due to one phase crystallisation also several types of inherited cores can be observed. Recrystallisation e.g. during a high temperature overprint can be detected by diffuse CL structures. Sometimes only the intensity of the CL signals varies.

The chemical and physical reasons why cathodoluminescence images of zircons show not only different structures but also different intensities are not known. Therefore, we measured systematically trace elements and REE in zircons using an ion microprobe. These ion microprobe analyses were done on magmatic rims and on inherited cores of zircons from granites of the Western Carpathians. The evolution and ages of these rocks are well known, also the ages of the analysed spots.

The REE patterns in our zircons indicate that the source is responsible for the distribution and concentration of the REE and clearly support the fact that the REE do not have any influence on the variation in brightness to the CL signal. The CL brightness shows a negative correlation with U and Hf concentrations, but a positive one with Th. All three elements U, Hf and Th have the same valence: 4+, and can therefore substitute the Zr in the lattice. The different influence of the three elements might be found in their different electron configuration. Whereas U as well as Hf has an incomplete f-shell that of Th is complete. Since luminescence is caused by electron transitions between discrete energy levels, such differences in the configuration might be responsible for this different behaviour. Our study could prove so far, that U and Hf are CL suppressing elements and that the CL signal is independent from the REE concentrations. Additionally, certain areas in zircons (rim / core) can be distinguished by their REE patterns and concentrations. Also it can be checked if areas of different zircons have the same origin.

These results represent a valuable tool for zircon geochronology since discordant core bearing grains are often evaluated together on a discordia line, assuming that they have the same origin. Until now, this assumption can not be proven for discordant grains. Rather often questionable discordia lines are drawn and thus the resulting ages are not always geologically meaningful. The REE patterns, as applied in our study, offer the opportunity to distinguish cores in zircons as coming from different sources. Consequently, the quality and interpretation of upper intercept ages characterising the protolith age of a rock can be improved by the REE analyses.